Comparison of Ground-Cover Materials for Container Growing Systems: Horizontal Versus Vertical Drain©

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This paper reviews the materials most commonly used as ground covers on Belgian container nurseries and reports on trials comparing their drainage characteristics. Older materials tend to discharge water horizontally (surface run-off), while newer materials are designed to drain vertically (below-surface run-off). The choice has implications for water management in the crop and for recovery and recycling of irrigation water.

INTRODUCTION

Before the 1980s, azaleas and most nursery plants in Belgium were field-grown. Since the 1990s much of this has been replaced by container-growing either on specially prepared drained beds or on covered soil.

The advantages of container production have been considerable for the Belgian industry. Plants grow much more hygienically, so pesticide and herbicide use is reduced (Alkemade, 1995). Containers stay clean, so less washing is needed before marketing. Working conditions for nursery staff are improved.

However one of the most important advantages, both environmentally and economically, is being able to recover the irrigation water draining from the beds. Depending on the type of covering system it is possible to recover some 50% of the irrigation water and almost 30% of the fertilizer applied to a bed. This enables growers in Belgium to meet local regulations regarding discharge of water from nurseries into soils or rivers. If the water is treated, for example by UV-lights or slow sand filtration, it can be recycled.

HORIZONTAL DRAINAGE (SURFACE RUN-OFF) COVER SYSTEMS

The soil is covered first by a plastic sheet over which a ground-cover material is used. The slope of the field should be approximately 1.5%. In some systems capillary matting is used between the plastic sheet and the ground cover (Pauwels, 2002). Aquafelt Plus is currently the only such material on the Belgian market. Other systems, such as Lysdrain and Hygromat, combine the three materials (plastic sheet, capillary mat, and ground cover) in one integral matting.

Plastic Sheet Plus Ground Cover. This system is the one most commonly used in Belgium when a horizontal drainage pattern is required. Weight ranges from 100 to 140 $g^{-1} \cdot m^{-2}$ with water permeability between 12 $L^{-1} \cdot m^{-2}$ and 20 $L^{-1} \cdot m^{-2}$. During dry seasons, the disadvantage of having no capillary matting is that more irrigation is needed. This also leads to significant variability in moisture content of the substrate between plants at the top of the bed and those at the bottom. On the other hand, during wet seasons, some capillary matting can retain too much water.

Plastic Sail + Aquafelt Plus + Ground Cover. Aquafelt Plus is a needlefelt with a fibre-blend of 100% polyester fibres and bicomponent fibres. This capillary matting is 1.1 to 1.6 mm thick. The absorption capacity is 0.6 $L^{-1} \cdot m^{-2}$, and it weighs 80 $g^{-1} \cdot m^{-2}$. In drier seasons or climates use of capillary matting as part of the ground-cover system leads to a faster and more even distribution of the water and a greater water retention. But for wet seasons, there are disadvantages associated with too much moisture in the substrate for long periods.

Lysdrain. Lysdrain and Lysdrain Plus are polypropylene cover systems that combine plastic sheet, capillary mat, and ground cover in one integral cover. Lysdrain Plus is heavier than Lysdrain. Lysdrain weighs 245 $g^{-1} \cdot m^{-2}$and has a water absorption of 0.4 $L \cdot m^{-2} \cdot sec^{-1}$, Lysdrain Plus weighs 283 $g^{-1} \cdot m^{-2}$and has a water absorption of 0.8 $l\ m^{-2} \cdot sec^{-1}$. In trials at Proefcentrum voor Sierteelt and elsewhere, this cover system gave very promising water retention results, during both dry and wet seasons (Pauwels, 2004; Morel and Berthier, 2005). However the sheets are not easy to connect when using them to construct larger container fields.

Hygromat. Hygromat also combines plastic sheet, capillary mat, and ground cover in one integral system. But its water retention capacity is too high to be suitable for a humid climate. Trials have also shown that this cover system is quickly colonised by algae.

VERTICAL DRAINAGE (BELOW-SURFACE RUN-OFF) COVER SYSTEMS

As in the horizontal systems, soil is covered first by a plastic sheet. The material on top of this sheet is designed for more vertical drainage, and the slope of the beds used with these systems can vary between 0% and 1.5%. Vertical drain systems result in more efficient watering and more air circulation. Sand beds were traditionally used in nursery stock where vertical drainage characteristics were required (Springer, 1998). Currently gravel or flex, bubbledrain, and lava (or crushed rock) are the most commonly used vertical drain systems in Belgium.

The ground cover material used for vertical systems is heavier than for horizontal systems. The lightest cover is 137 $g^{-1} \cdot m^{-2}$ with a water permeability of 20 $L^{-1} \cdot m^{-2}$. Mostly a cover of a weight between 205 and 230 $g^{-1} \cdot m^{-2}$ is used.

Gravel or Flex. On top of the plastic sheet, a 3-cm layer of gravel is laid and stabilised by a net and covered with a ground cover. For fields with a 0% or a minimal slope, drain tubes are necessary. Optimum bed width is not more than 25 m.

Bubbledrain. This system is based on a high density polyethylene bubble sheet, laid on top of the usual plastic soil-cover sheet in strips, perpendicular to the drain direction. Although the Bubbledrain is impermeable, the plastic sheet beneath is still needed, because a 5-cm expansion gap is required between the strips. The bubbles are 8 mm deep.

The Bubbledrain is overlaid by a firm 1-mm-thick groundcover material. The method of fixing the ground cover at the bottom of the container bed is important to avoid accumulation of water below the bed (van den Berg, 2005).

Lava. A 5- to 10-cm layer of lava (1 to 11 mm) is laid on top of a plastic sheet (Molenaar, 2004). The bed slope in these systems is usually 0%, and drain tubes at the bottom of the bed remove the drain water. A medium- to heavy-grade ground cover

lava + GC (200K) Irrigation on top	lava + black-white GC Irrigation on top	bubbledrain +aquasorb Irrigation on top	bubbledrain + GC (137K) Irrigation on top	bubbledrain +aquasud Irrigation on top	porous material Irrigation on top
plastic + aquasorb Irrigation on top	bubbledrain +aquasorb Irrigation from below	bubbledrain +aquasud Irrigation from below	lysdrain plus Irrigation on top	plastic +GC Irrigation on top	gravel Irrigation on top

Figure 1. Scheme of different cover materials outside the greenhouse.

Figure 2. Plants in the beds outside the greenhouse.

is laid over the lava but not so heavy that it supports weed growth. In these systems it is important to irrigate the bed before containers are stood down, especially in dry seasons; otherwise the lava will draw water from the containers.

TRIALS AT PROEFCENTRUM VOOR SIERTEELT

At the Research Station for Ornamentals at Destelbergen, Belgium, an experiment was carried out over several years to compare the performance of different

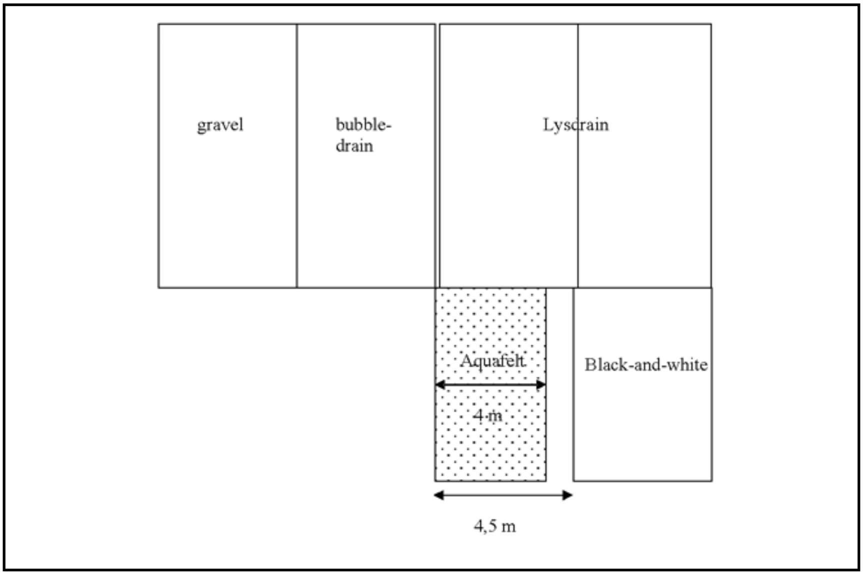

Figure 3. Scheme of different cover materials inside the greenhouse.

cover materials, including both horizontal and vertical drain types, both outside and under protection.

Materials and Methods. Outside, 12 beds each of 100 m^2 were covered (Figs. 1 and 2). Each bed had its own collection tank of 1500 litres. Irrigation was applied to a container crop on the beds based on irradiation sum. This sum was equal for all horizontal systems. For the systems with Bubbledrain, the sum was lower (faster irrigation), and for the lava, flex, and the porous material, the irradiation sum was even less.

There were also six beds inside a greenhouse (Fig. 3), each of 150 m^2. Again, irrigation to a container crop on the beds was based on irradiation sum.

For both the outdoor and greenhouse beds we measured the amount of irrigation ($L^{-1} \cdot m^{-2}$); moisture content of the substrate in the container (HH2 moisture meter); temperature in the container; nutrient analysis in growth medium; nutrients analysis in the run-off water; root growth and plant quality.

RESULTS AND DISCUSSION

The irrigation frequency on each bed depended on the irradiation sum. The number of litres for each irrigation was the same, namely 8 $L^{-1} \cdot m^{-2}$. Generally Bubbledrain needed approximately twice as much irrigation as any of the horizontal drainage beds. Flex, lava, and porous material needed between two and three times more irrigation than the horizontal-drained beds.

The average drain percentage (i.e., the proportion of water applied to the plants that is recovered from the drain) for the horizontal systems was 30%. Draining was faster in the vertical systems, and the average drain percentage was approximately 60%. The capacity of the water recovery system and disinfection installation required will depend on the drainage percentage.

The moisture content of the growing medium also depends on the irrigation and on the drainage characteristics of the bed. We recorded remarkably small differences in moisture content of the substrate between plants at the top and bottom of the bed with vertical draining systems.

Temperature differences in the pot were small between systems. Temperature fluctuations were smaller for vertical systems, because of the more frequent irrigation.

There were few and small differences between nutrient analysis in the growth medium and in the drain water for any of the systems but the porous materials resulted in higher proportions of sulphates in the drainage water.

Root growth was always better in crops grown on vertical-drained systems, but other aspects of plant quality did not differ. Hygromat resulted in more plants attacked by *Cylindrocladium scoparium*.

CONCLUSIONS

Currently, the cost of a horizontally drained container bed is approximately 10 € per m^2 (all inclusive). Use of special ground covers such as coated Aquasorb and Lysdrain or Bubbledrain adds a little to the material cost. The most expensive materials are lava and gravel, for which the material costs are approximately equal to the total cost of a horizontal-drained bed.

Vertical drain systems are very satisfactory, certainly for wet seasons when the water can be drained more easily. Rooting is mostly better for these systems. Lava, firm Bubbledrain, and gravel are convenient for automated beds.

For environmentally responsible production both systems should only be used as part of a collection and recycling regime for the irrigation water.

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